Menlo Park Notebook #116 [N-80-07-27]

This notebook covers the period July-November 1880. The entries are by Charles L. Clarke. The book contains calculations, notes, and drawings relating to dynamos and steam engines for the jumbo dynamo. There are also tests of dynamos and motors, using meters with depositing plates to measure the current, and tests of the insulation for the electric railroad track. The label on the front cover is marked "C. L. Clarke." The book contains 284 numbered pages.

Blank pages not filmed: 222-257, 262-274, 277.

Missing page numbers: 275-276.

xE-172 N-80-07-27

9 x 10

81
10
810 at 120 developes 100
120
16200
81 0
97200

3,5 x 8
3,5
175
105
12,25
8
98~~00~~
60
5880~~00~~
~~5880~~
2940000

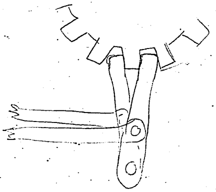
97200
600
58320000

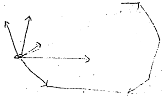
Clarke

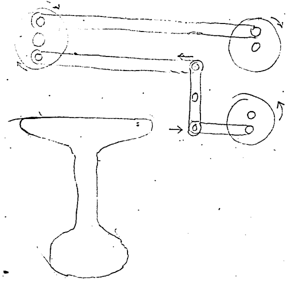
2940000
100
58320~~00~~) 294000000 (5
29160
5
25

Supt. of engineering
M. Haines Manhattan.
New York

60
12







Dynamo-electric Machine.

30 to 1 Resistance

75 lights

105 Volts at 600 revo.

2 Turns of 8 wires

Wire $\frac{87}{100}$

armature

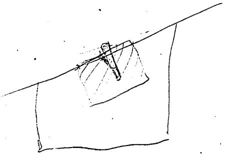
20 " long

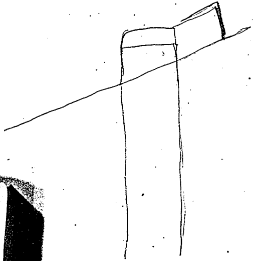
14 " diam.

51 commutators.

Proportions for Dynamo.

July 27, 1880.





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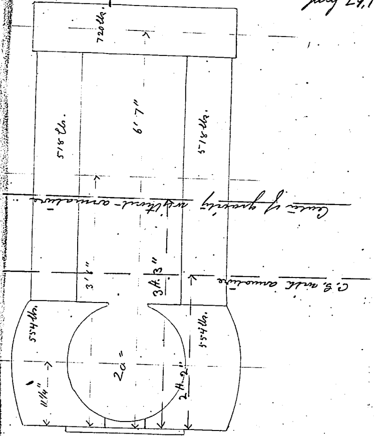
Determining Center of Gravity

20" Dynamo

July 29, 1880.


720 lbs.
518 lbs.
6' 7"
518 lbs.
Center of gravity without armature
3' 1"
3 ft. 3"
C.G. with armature
554 lbs.
554 lbs.
20"
11 1/4"
2 ft. 2"

518
518
1036
42
2072
4144
43512

554
554
1108
11,25
5540
2216
1108
1108
1246500
56880
43512

79
720
1580
553
56880

2864)112857(39"
85927
26937

3' 3"

720
1036
1108
2864

Weight of armature with shaft some 2500 lbs.

11,25
2500
562500
22.50
2812500
112857

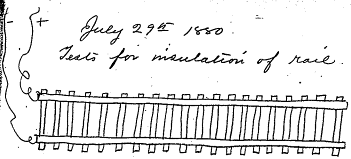
2864
2500
5364

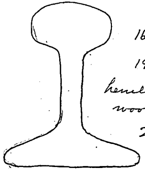
5364)140982(26 inches
107287
33702
32184

2 ft 2".

July 29th 1880.

Tests for insulation of rail.





16 lb. rail.

19 sleepers of hemlock cord-wood.

24 ft. rail.

After being laid down upon a grass plot and spiked and allowed to remain a week, during which time there were heavy rains the resistance was measured. The grass was dry and sky clear. The resistance was 8900 ohms, as the spikes on one side were drawn the resistance rapidly increased.

And when all the spikes had been

drawn ~~and~~ on one side and that rail rested on the two end sleepers the resistance was;

290 000

When a man stood on the rail at each sleeper on the end,

220 000

When a middle sleeper was in contact also,

250 000

When man touched it with his hand it was

100 000

When all the ties on that side were in contact but spikes drawn the resistance was 75000.

Spikes pulled on both sides and rails supported on end ties and ties not well grounded

1600000

Man standing on three points of support 16 0000

One rail taken off sleeper and laid on ground, other rail supported on ends, and contact points and rail resting on ground wet,

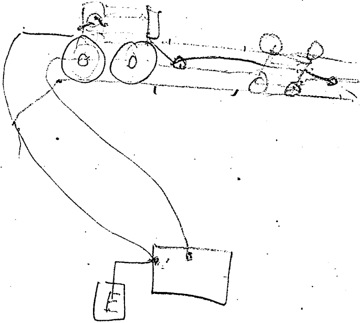
250 000

Rail wet on ground and other end of circuit grounded

450

again 100000

The grounding of the rails is the principal cause of fall in resistance and not directly through the ties as their resistance is very high.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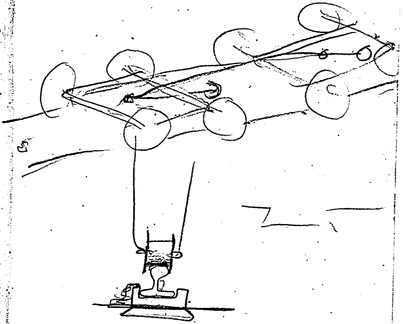
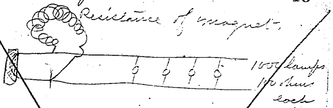


~~Aug. 7, 1880~~

~~Resistance of magnet.~~



~~Resistance of magnet 30 ω.~~

~~1 : If 1000 lamps are in circuit the resistance of circuit wire be $\frac{1}{10}$ ohm, therefore resistance of magnet is 3 ohms.~~

~~Then with 100 volts at machine we have~~

~~$\frac{1}{3} + \frac{10}{1} = \frac{31}{3}$. Resistance with magnet is $\frac{3}{31}$ ohms.~~

~~∴ $\frac{1}{10} : \frac{3}{3} :: 100 : 96.8$ Volts~~

~~$\frac{300}{31} \times 10$~~

```
31)3000(96.8
   279
    210
    186
     240
```

~~A fall 3.2 Volts~~

100
50
100
50

~~Aug. 7, 1880.~~

~~Now supposing only 100 lamps in use.~~

~~The resistance of line will be 1 ohm.~~

~~∴ $\frac{1}{3} + 1 = \frac{4}{3}$; therefore resistance of line including magnet will be $\frac{3}{4}$ ohm.~~

~~∴ $1 : \frac{3}{4} :: 100 : 75$~~

~~a fall of 25 Volts.~~

~~If only one lamp is in use, the resistance of line is 100 ohms and including magnet $\frac{300}{103}$ ohms.~~

~~[illegible]~~

~~∴ $100 : \frac{300}{103} :: 100 : 2.9$~~

~~103)300(2.9~~
~~[illegible]~~
~~940~~
~~[illegible]~~
~~1160~~

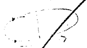
~~a fall of 97.1 Volts.~~

$\frac{1}{2}+\frac{1}{30}$ $\frac{16}{30}$

$\frac{16}{30} : \frac{15}{30} :: 100$

$16)\,1500\,(93.7$

[illegible]



~~100 lamps.~~

~~30 to 1~~

~~1 ohm~~

~~1/30 ohm~~

~~31/30 : 30/30 :: 100 :~~

~~31) 3000 (96.8~~
~~279~~
~~210~~
~~186~~
~~240~~

~~106~~

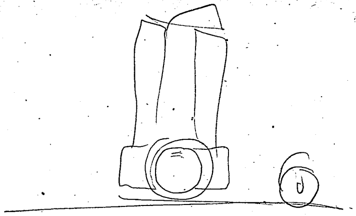
~~30 to 1~~

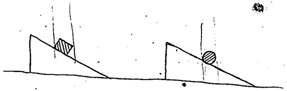
~~100/106 ohm~~

~~100/106 + 1/30~~

~~3000~~
~~106~~
~~3106/3180 : 3180~~

~~3180) 310600 (97.~~
~~28620~~
~~24400~~
~~22260~~
~~2140~~

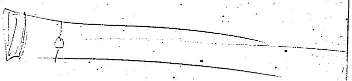


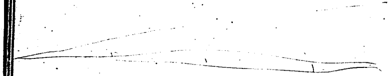


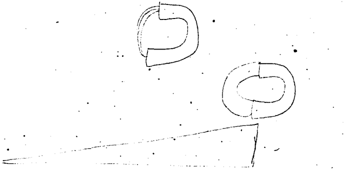
$\frac{100}{106}+\frac{1}{30}=\frac{3000+106}{3180}=\frac{3106}{3180}$

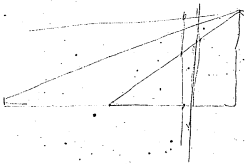
$\frac{3106}{3180} : \frac{3000}{3180}$

$3106)\,300000\,(96.6$
27954
20460
18636
18240

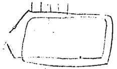


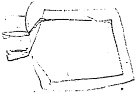


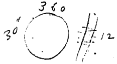




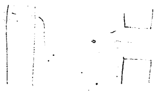
```
772 ) 165000 (214
      1544
      ----
       1060
        772
       ----
       2880
```

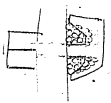


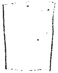




30
23







Basic Experimental Aug. 11, 1880.

100 revo. give 8 volts with 75 turns. 19½" armature. 75 commutator blocks.

at 600 revo. 48 Volts.
If armature 3 times as long will give 144 Volts.

115 Volts will run present lamps. 9 2/10 per H.P.

About 135 Volts are required for the machine.

144 : 135 :: 75 com. to 70.3 com.
Since 71 and 73 are prime 69 commutators are taken which will give 132 Volts. 23

Calculation
for
Commutators

Diam. of plate 19.5"
69 turns or 138 divisions.
Circumference of 61.2".

138) 61,20(,4435
55 2 x
600
552
480
414
660

4

,444" for each division.

.02" for peg and .02" for insulation
Say .05" for separation.

,444.-,05 = .394" for wire

Diam. of plate 19.5"

69 turns or 138 divisions.

Circumference of 61.2".

```
138) 61.20(.4435
     55 2 x
       600
       552        4
        480
        414
         660
```

.444" for each division.

.02" for peg and .02" for insulation

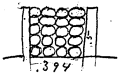
Say .05" for separation.

.444 - .05 = .394" for wire

Commercial Wire.

4, 5, 7, 8, 9, 10, 12; 13, 14, 16, 18, 20, 22.

Cross section of Wire



.394
.5
.1970

.009 in each wire for insulation

.394
.036
.358

.5
.045
.455

Actual space occupied by copper wire. .358" × .455"

4 | .358 .455
.089 .111

Wire 9/100" diam.

9/100 or 8100 circular mils.

20 wires give
162,000 circular mils.
in section.

Length of armature
29".

Diam. at center of wire 20".

Allow 5" for ends.

making 29+20+5 = 54" ×2 = 108"
or 9 ft of wire for complete
turn. There are 69 comm.
69 × 9 = 621 ft of wire on
machine, which has resistance
of equivalent size and
1/4 the length or
155.2 ft.

Resistance of mil-foot
10.64 Ohm.

Resistance of machine
= $\frac{10.64 \times 155.2}{162000}$

155.2
10.6 4

6 2 0 8
9 3 1 2
1 5 5 2

162~~000~~) 1.6 5 1.3 2.8 (.0102
1 6 2 x x

3 1 3
3 2 4

Lamp 165 ohms.

Take 800 lamps

$\frac{165}{800}$ Ohms resistance

800)165(

.206 Ohm.

A ratio of .206 to .0102

or 20 to 1

at 132 Volts.

2) 3.1416
1.5

$\overline{132}^2 : \overline{115}^2 :: .0102 :$

115
115
575
115
115
13225
.102
26450
13225
17424) 134.8950 (.00774 Ohms.
121968
129270
121968
73020

132
132
264
396
132
17424

.206 : .00774 :: 26.651.

.00774) .20.6.00 (26.6
1548
5120
4644
4760

Aug. 11. 1880.

Size of commutator block on circle 8¼" diam.

69 Blocks

3.1416
8.25
157080
62832
251328
25.9182~~00~~ inches circum.

allow 1/16" insulation

69) 25.9182 (.3756
207xxx
521
483
388
345
432
414

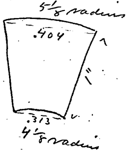
1/16 = 16) 1.00 (.0625
96
40
32
80
.80

.3756
.0625
.3131

Outside diam. 10 1/4".

```
    3.1416
     10.25
  --------
   157080
   62832
  31416
69 )32.201400 ( .4667
    27 6
    ----
     460
     414
     ---
      461
      414
      ---
      474
```

```
 .4667
 .0625
 -----
 .4042
```


5 1/8 radius
.404
1"
.313
4 1/8 radius

```
.404  .3[illegible]  .35
        1430
        140
```

```
  .404
   .35
  ----
  2020
 1212
 -----
 .14140
```

3.1416
16
158496
31416
69) 50.2656 (.7285
48 3
196
138
585
552
336

.729

$6\frac{7}{100} = \frac{37}{500}$

1/16

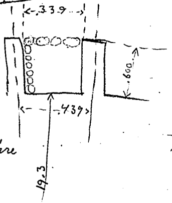
31416
49.5
157080
282744
31416
61.26120

.729
.0625
.6665

Drain,

3.1416
19.3
94248
282744
31416
138) 60.63288 (.439
552
543
414
1293
1242

20.5
19.3
2)1.2
.6



.439
.100
.339

7/100 drain,
of wire

25
4900
25200
112
137200

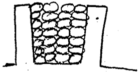
80
80
6400

28
6400
11200
168
179200

If $\frac{9}{100}$ diam. including insulation $9 \times 4 = 36$

$.439 - .36 = .079 = \frac{8}{100}$

separation.



7

$3\frac{17}{32}$

.437
.32

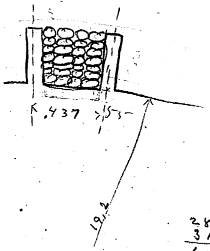
.107

.10

180000

3 X 6

200000



20.5
19.2
2/1.3
.65

.7

3.1416
19.2
62832
282744
31416
60.31872

138/60.31872(.437
552XX
511
414
978
966

Wires $\frac{8}{100}$ diam. or $\frac{9}{100}$ with insulation.

.437 - .36 = .077 for separation

6400

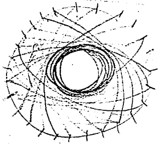
28
6400
11200
168
179.200 Circular mils,

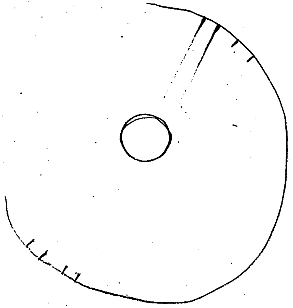
179200 : 162000 :: .0102 :

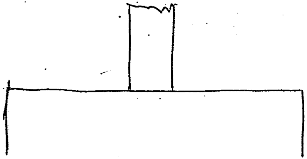
.0102
162000
204000
612
102
179200) 1652.4000 (.00922
1612.84
3960
3584
3760

.206 to .00922

or .00922) .20600 (22.
1844
2160
1844
3160







3/4

9 1/4
3 1/2
19)5.75(.303
57
50

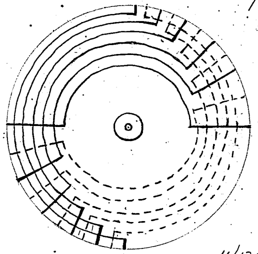
3.5
.301

.0625
.031

3.5
.303
3.197
.03125
3.22825

.303
.0625
.2405

Aug 21,
1880.

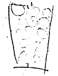


4)138
34 1/2

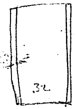
3.1416
~~10~~ 10 1/4
31.4160
7854
2)32.2014
16.1

3.1416
3 1/2
94248
15708
2)10.9956
~~5.5~~

20.5
7
13.5
11
2.5



.433
.32
.113
.11
.013



32) 23.0 (.71875
22.4
60
32
280
256
240
224
160
160

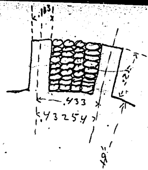
100
75 000
10000
15 0000

3.5
.301
3 199/1000

19) 5.71875 (.301
5 7
18
.23 85

9 7/32
3 10/32
5 23/32

Aug. 23.
1880.



3.1416
19.
282744
31416
59.6904

138) 59.6904 (.4325
55.2
449
414
350
276
744

113 : 320

433
113

20.5
19
2 11.5
.75

8 | .433 . 75
.4 + .113 . .9 + .03

4 by 9 wire 8/100" diam. with insulation or 7/100 of copper.

740
4900

36
4900
32400
144
176400

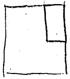
744
690
540
452

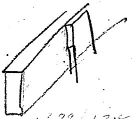
176400 : 162000 :: .0102 :

.0102
162000
204000
612
102
176400) 165240 (.0093
158767
6480
5292

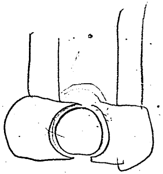
.0093) .2060 (.22
186
200

22.51 with lamps at 165 ohms.





.299).13.85(.46
1196
1890



.24).1385(.5
120
8

.24).1385(.58
1207
185
192

$\frac{6}{10}$

$\frac{5}{8}$ .62

---

4)138
69
2
34½

Aug. 23, 1880.

176400 circular mils

176400(420/1000 diam.
16
82)164
164

1000
1000
1,000,000.

Radius = $\frac{21}{100}$

.21
.21
21
42
.0441

3.1416
.0441
31416
125664
125664
.138544456 Sq. inches

.42
.42
84
168
1764

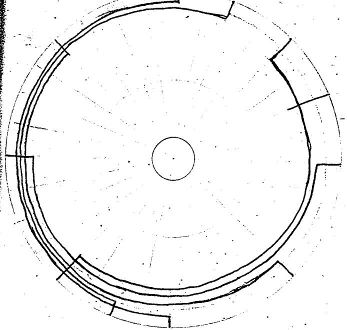
is the end area of each bundle of wire in copper.

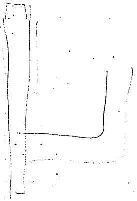
3.1416
6
2)18.8496
34.5)9.4248(.273).1385(.5
690
2524
2415
1098
.1365

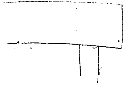
.25).13854(.55
1254
135
125

.5).139(.28
100
39

.625).1375(.22
1250
1250
1250



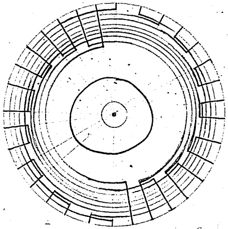




End connections
for armature coils.

Aug. 23, 1880,

Clarke,



1½

34)5.0(.147
136
240
.08

6

.23)5.12(.22

6)138
23
46

2)34
17

.25).13850(.554
125
.135
.125
.85

44)138
34½

.554

17)6.00 (.3000
.0625
.2375

3.45)6.000(.17
345
3415

$5.25 : 5.25 + 4.25 :: x : 69$

```
     5.25
       69
    4725
   3150
9.5 )362.25 (38.1
     285xx
      770
      760
       105
        95
```

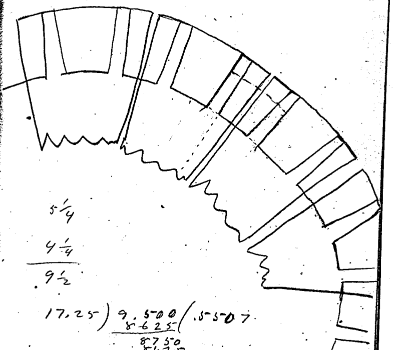
```
69
35
2)34
 17½
```

```
2)34
  17
```

Aug. 3, 1880

Clarke.

```
2)138
4)69.
  17¼
```



5¼

4¼

9½

```
17.25) 9.500 (.5507
       8625
        8750
        8625
         12500
         12075
```

```
16 )100(42
     1
     40
     32
     80
```

1/16 =

```
.5507
.0625
.4882
```

$3\frac{1}{2}$
$5\frac{3}{4}$
$9\frac{1}{4} - \frac{1}{32}$
$9\frac{8}{32} - \frac{1}{32} = 9\frac{7}{32}$

$\frac{39}{17}$
$\frac{22}{32} = \frac{11}{16}$

.0625
18
5000
625
1.125~~0~~

$9\frac{7}{32}$
$3\frac{17}{32}$
$5\frac{11}{16}$

16)11.0(.6875
96
140
128
120
112
80
80

19)5.6875(.299342
.0625
38
188
171
177
171
65
57
80
76
40
38

5.6875
1.125
19)4.5625(.240
38
36

17)5.0(.3
51

.3).1385
.46

19)5.25(.2763
38
145
133
120
114
60
57

38
31
69

.2763
.0625
.2138 is width of copper rings on 19 side

.2138).138544(.65
.128284
10264
10690

The height is .65 ".

---

16)4.25(.2669
32
105
96
169
140

.2669
.0625
.2044 is width on 15½ side.

.2044).138544(.677
122644
15904
14308
15960

$10\frac{2}{8}$
$\frac{7}{8}$
$9\frac{3}{8}$

The height is .68

4|69
17¼

18} 36
17} 34

18 and 18
17 and 16

18)5,75(.32 distance between
5 47
35
36

Centers of strips

$\frac{1}{16}$ = .32
,0625
,2575 is width of

Copper rings on 18 side.

17)5,75(.34 distance between
5 1 4
65
68
Centers of strips.

$\frac{1}{16}$ = .34
,0625
,2775 is width of

copper rings on 17 side.

19)5,75(.303
57
.50
.0625
.2405

~~.7912~~

.7912
.20
2) .5912

3.1416
21.5
157080
31416
62832
69) 67.54440 (.9789
621 x x
544
483
614
552
620
621

.9789
.0625
.9164

.9789
1.5
48945
9789
2) 1.46835
.73418
.0625
.67168

69) 59.6904 (.8651
552 x x x
449
414
350
345
54

.8651
.0625
.8026

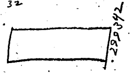
3.1416
20.5
157080
62832
69) 64.40280 (.93337
621 x x x
230
207
232
207
258
207
510

.93337
.0625
.87087

$3\frac{1}{2} + \frac{1}{32}$

$3\frac{16}{32} + \frac{1}{32}$

.236
.0625
.2985



$9\frac{3}{8}$
2
18.75

3.1416
18.75
157080
219912
251328
31416
69) 58.905~~000~~ (.8537
552 x x
370
345
255
207
480
483

.8537
.0625
.7912
.32
2) .4712
.2356

$10\frac{1}{4}$
$\frac{3}{4}$
$9\frac{1}{2}$

.53506
.0625
6) .47256
.07876
~~.8537~~

.7912
.32
2) .4712
.236

.8537
.64
2) .2137
.1019

.8537
1.5
42685
8537
2) 1.28055
.64028
.64028
.236
.236
1.0625
1.81566

~~.8537~~
~~.75~~

.64028
.0625
.57778

1.81506
1.28
6) .53506
.089

.578
.578

.7912
.0625
.578
.0625
.578
.0625
.7912

2.9159

32) 17.0 (.53125
16 0
1 00
96
40
32
80
64
160
160

.236
.32
.08876
.32
.08876
.32
.08876
.0625
.08876
.32
.08876
.32
.08876
.32
.236

~~[illegible]~~
2.92706

3.53125
.3615
3.16975

.0625
.299
.3615

3.53125
.3065
[illegible]

.0625
.264
.3065

15
4
900

$\frac{5}{8} \times \frac{3}{16} = \frac{15}{128}$

128) 15.0 (.117
12 8
2 20
1 28
920
896

.117/10000
.117 [illegible]

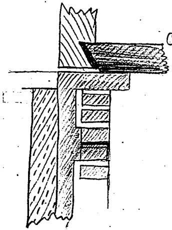
$10\frac{1}{8} =$

10.125
3.1416
60750
10125

[illegible]

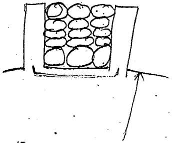
Sept. 1, 1882.

Commutator Side.
Clarke


Commutator Block.

Clarke

Sept. 10. 1880.



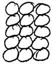
3 × 5

1.5 inches

$\frac{10}{100}$

3.1416
19.5
157080
282744
31416
138)61.2612(.443
552xx
606
552
541
414

.505



64)1.00(.015625
64
360
320
400
384
160
128
320
320

.015625
3
.046875

.5
.046875
.453125

1/32

.047
.4
.5
.447
2).053
).026

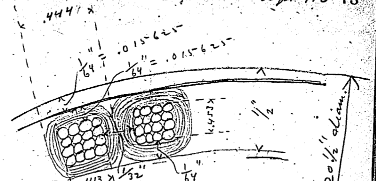
.047
.020
.067
.4
.467

.5
.467
2).033
2).0165
5

36

44/1000 = 22/100

1/4


.4441
1/64" = .015625
1/64" = .015625
.453
1/2"
20 1/2" diam.
.413
1/32"
1/64"

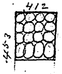
.5
.0313
.4687

20.5
.9374
19.5126

.4687
.0156
.4531

3.1416
19.5
157080
282744
31416
138.)61.26120(.4439
552
606
552
544
414
1272
1242
300

.4439
.0313
.4126



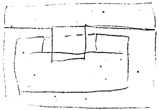
available space for wire.

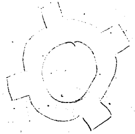
See page 77.

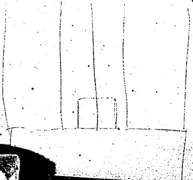
16 wires 100/1000 diam.

$\overline{100}^2 \times 16 = 160000$ circular mils

Since the wires actually take up .4 in both directions we have .053 in radial and .013 in circumferential

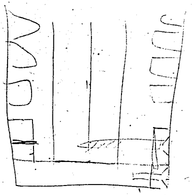


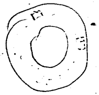


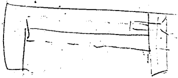


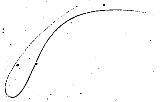
direction for insulation in addition to what has been already allowed

.40
.33









.05
.02
.025
.4
.495

15 to 2 — .52
.07
.45
.40
.003).050
~~.002~~)~~.0~~17
~~.0~~8

3.1416
19.51
31416
157080
282744
31416
138)61.292616(.444
552
600
552
572
552
206

2).444
.003).022
.7

20.5

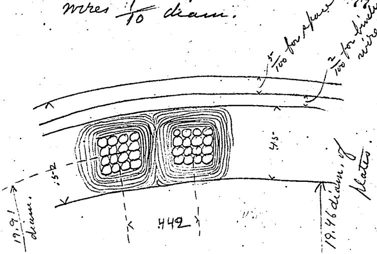
10.25
.495
9.755
2
19.510

10.25
.52
9.73
2
19.46

19.46
.75
19.385
3.1416
116310
19385
77540
19385
58155
138)60.899160(.441
552
569
552
179

19.46
.45
2)17.91
9.95

wires 1/10 diam.


5/100 for space
2/100 for binding wire
.52
45
.442
19.91 diam.
19.46 diam. of plates

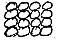
7 turns of 3/1000 tracing linen wire fill up space between bundles. 8 turns will fill up allotted space of .45 radially.

Sept. 10,
1880,
Clarke.

2)19.46
9.73

.05
.05
.0025

3.1416
.0025
157080
62832
.00785400
16
47124
7854
.125664 sq. in. is the actual cross-section of copper in the strands in armature.



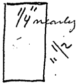
.126 sq. in. of copper.

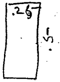
.25).126(.5
.125

Sept 17, 1880 Clarke

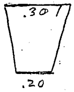
If it is made into solid block 1/2" deep the thickness must be

.50).125664(.25
1004
256
250





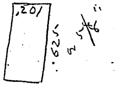
.25 This may be made into a trapezoid



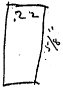
Sept. 17. 1880. Clarke

If we allow the depth to be $\frac{5}{8}$" = .625" then the width would be .201

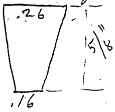
.625) .125664 (.201
.1250xx
664
625



We will allow however .22 for width to allow for brazing and imperfect moulding



or in the trapezoidal form

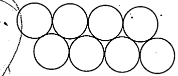


44

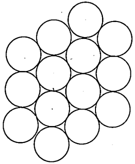
315 11x44

26

$C_{16}H_{20}$.



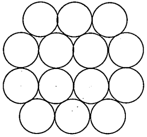
$C_{20}H_{8}$ / n

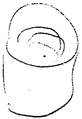


R.

130.

9:





Sept. 28, 1880.

Experiment on heating of copper rods revolved through the magnetic lines of force.

Temp. of atmosphere at commencement 76°.5 F.

Temp. of Iron Plates of Armature 77°.5 F.

Temp. of Fields 81° F.

Time of Commencement 7-27 P.m.

No. revo. per m. 136.

After revolving 10 m. in strong field the temp. still remained 77° F.

Started again at 7-40 p.m.

No. revo. per m. 240

Field strengthened

Temp. of atmosphere remains constant. 76°5 F.

After running 30 m. no perceptible heat.

Third test commenced 8-30 P.M.

No. revo. per m. 300.

30 minutes duration of exp.

Copper bar went from 80° to 87.

4th test

Commenced 9-7 P.M.

No. revo. per m. 300.

Duration 1 h.

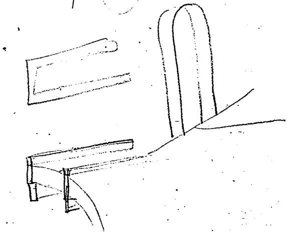
Temp. at end 88°F.

Temp. of air 76°F.

See page 89

203) 787.836 (3334) 33000 (9
30006
609
788.
609
3.
799
609 6.
842
3 5 1 2
7

144



17769
44
71076
71076 6
78183
6000 0
6
78783

144
7
137
137
959
31 1
137
177 6 9

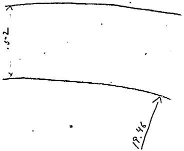
Test-continued Sept. 29, 1880 Clarke.

Wednesday.

Temp. of air	77° F.
Time	4-30 P.M.
Temp. of copper rods	78° F.
Revolutions per minute	280.
" Second test	310.
3rd "	310
Temp. of copper rods after 1 hour	80°F.

No appreciable rise in temperature was found to have taken place by revolving rods of copper in the magnetic field therefore no injurious local currents and it was decided to adopt rods of large size instead of wires across face of armature.

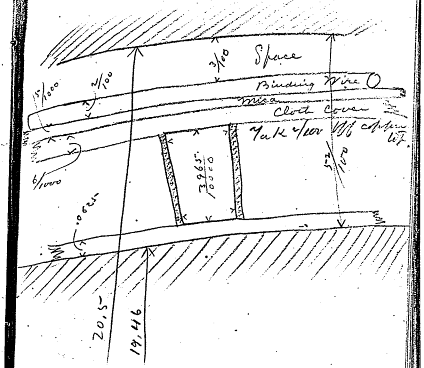
20.5
1.04
19.46



.03
.025
.006
.3965
.0625
.52

Sept., 30, 1880.

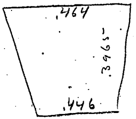
Clarke.


3/100
Space
Binding Wire
15/1000
2/100
Mica
Cloth Cover
Talk 2/100
6/1000
3965/10000
52/1000
.0625
20,5
19,46

Sept, 30,
1880
Clarke.

19.46
.793
.125
20.378
3.1416
122268
20378
81512
20378
61134
~~61139~~
138) 64.0195248 (~~.4639~~
552
.464
881
828
539
414
1255
2

19.46
.125
19.585
3.1416
117510
19585
19540
78340
19585
58755
138) 61.528236 0 (~~.4459~~
552
.446
632
552
808
690
1182



.464
.446
2) .910
.455

.3965
.455
19825
19825
15860
.1804075 sq. in.

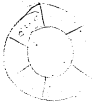
The former made of 16 strands of 1/10 wire had section of .126 sq. in. So the ratios of resistance will be 126 : 180

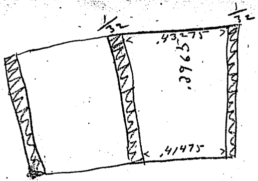
$\frac{126}{180} = \frac{63}{90} = \frac{6}{9} = \frac{2}{3}$

but take out insulation and

2

,02
,01





$\frac{1}{16} = .0625$

$\frac{1}{32} = .03125$

,464 - ,03125 = ,43275

,446 - ,03125 = ,41475

$2\overline{),84475}$

,42375
,3965

211875
254250
381375
127125

,16801687^5

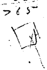
Therefore 126 : 168

$\frac{126}{168} = \frac{63}{84} = \frac{9}{12} = \frac{3}{4}$

,21638

9/2 See next page

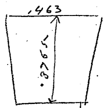
.3965
.0202
.3765



287

39

.3965
.02
~~.0625~~
~~.006~~
~~.003~~
~~.02~~
~~.03~~
.5400



Take off .02 from top of Copper rods

19.46
.125
.753

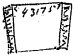
20.338
3.1416

122028
20338
2
81352
20338
61014

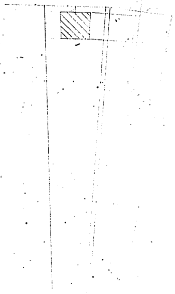
138)63.8938608 (.463
552
869
828
413
414

.463 less insulation

.463 − .03125 = .43175



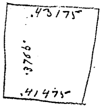
,0625



,43175
,41475
2),84650
,42325
,3765
211625
253950
296275
126975
.15935 3625

126 : 159

$$\frac{126}{159} = \frac{42}{53} = \frac{7}{9}$$

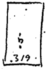

.43175
.3765
.41475

$\frac{1}{16} = .0625$

$\frac{1}{32} = .03125$

$\frac{5}{32} = .15625$

$\frac{7}{8} = .87$



If we assume depth to be half an inch at ends then

```
.5 ⌊.159353625
    .318707725 will be the
```

average width

```
.318707725        163
.15625            156
.16246.725        .319
```

Assume average width to be $\frac{3}{16} = .1875$ we have

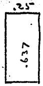
```
.1875).159353625 ( .85
       15000
        9353
        9375
```

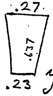
Assume average width to be $\frac{1}{4} = .25$

```
.25).159353625 (.6374
     150
       93
       75
       185
       175
        108
```

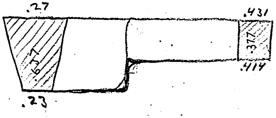
The height will be .6374

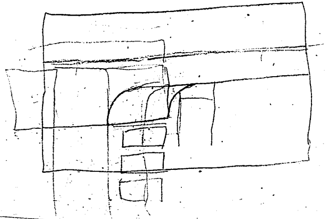
Then





This is actual dimension to which block is to be made at ends.


.27
.637
.23
.431
.377
.414



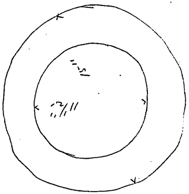
3,1416
19,46
188496
125664
282744
31416
138) 61.1355536 (,443
552××
593
552
415
414

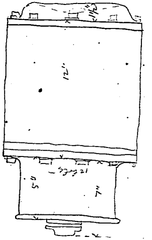
3,1416
20,5
157080
62832
138) 64,402 8 0 (,466
552×7
920
828
922

1132

$\frac{5}{8}$ = .625
,24
2500
1250.
.15000

,431
,414
2) .845
,14225
377
29575
29575
12675
.159 2825




1½"
12"
12 feet
5"
7"

120 H.P. dynamo Nov. 18, 1880.

at 600 revolutions gives
132 Volts, see page 23.

If another magnet is added and
only 450 revolutions the E.M.F.
will be

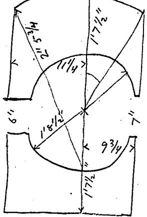
$$132 \times \frac{\cancel{4}}{\cancel{3}} \times \frac{\overset{15}{\cancel{450}}}{\underset{\cancel{4}}{\cancel{600}}} = 132 \text{ Volts.}$$

B

Calculations for Buckeye Engine.

The engine to run at 450 which is 3/4 of 600 revs. for Porter Engines. Masses of iron to be made 1/3 larger.

Clarkes. Nov. 19, 1880.



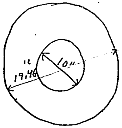
1st
100 H.P.
Constructed for Porter Engine at 600 revs.

When drawn to a scale of 3" to one foot the length of magnets on the face is 7 inches.

The end area is 14.3 sq. in for upper field + 14.9 sq. in for lower field,
Total is 29.2 sqr. inches.

The contents will be
29.2 × 7 = 204.4 cu. inches.

Clarke.
Nov. 19
1880.



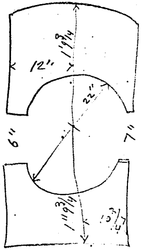
The diameter of the armature core is 19".46 and hole..10" diam. The end area will be

19.46
19.46
11676
7784
17514
1946
378.6916
100.
278.7

4)278.7
69.7
3.14
2788
697
2091
X 218.858 sq. in
28

And contents
1750864
437716
X 6128.024 cu. in

The Dynamo for the Buckeye Engine. Clarke. Nov. 19. 1880.



Area of upper field 17.7 sq. in.
+ Area of lower field 18.7 sq. in.

Total 36.4 sq. in. of end area
on a scale of 3" to 1 ft.

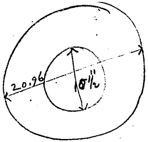
If the magnets are 32"
long on the face the contents
will be 36.4 × 8 = 291.2 inches

Clarke, Nov. 19, 1880

Compare this with contents on page 117, $291.2 - 204.4$
$= 86.8$

Then $\frac{868}{2560}$, about 1 to 3, which is the desired proportion _

$$\begin{array}{r} 22.00 \\ 1.04 \\ \hline 20.96 \end{array}$$



The outside diameter of armature core will be 22" – 1.04 = 20".96
And suppose it necessary to increase the shaft from 4½ to 5", which will make the hole 10½" diam.

Clark. Nov. 19, 1880

The end area will be

$439 - 110 = {}_4\underline{329}$

$82{,}25 \times 3{,}14$

= 258 sq. in. and if 32" long, 258 × 32 =

8256 cu. inches

Compare with page 119.

$8256 - 6128 = 2128$

$\frac{2128}{6128} = 1$ to 3 which is the desired proportion.

22.
20.968
1.032
.516

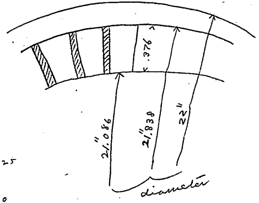
20.50
19.46
1.04
.52

21.03
20.968
2).062

20.5
19.46
1.04

22
21.086
.914

Clarke, Nov. 19, 1880.

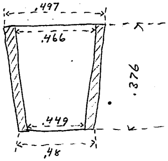

.376
21.086"
21.838"
22"
diameter

22.162
21.838

21.838
.752
21.086

32) 1.00 (.03125
96
40
32
80
64
160
160

21.838
3.1416
131028
21838
87352
21838
65514
138) 68.6062608 (.497
552
1340
1242
986
966


.497
.466
.376
.449
.48

21.086
3.1416
126516
21086
84344
21086
63258
138) 66.2437776 (.48
552
1104
1104

~~497~~
~~3125~~
~~.545~~

497
03125
.46575

48
03125
44875
.46575
.91450

.15886
.02227

.1515

.4575) .18150 (397
13725

44250
41175

30750

Clarke, Nov. 19, 1880.

2).9145

.4575
.376

27450
32025
13725

.1720200 sq. in. is the end area of the copper rods across the face of armature.

.431
.414

2).845

.4225
.376

25350
29575
12675

.1588600 sq. in. is the end area of copper rods for Porter Allen Dynamo.

.172
158

14

14)158(11
154

18

the ~~resistance~~ area is ~~diminished~~ increased by $\frac{1}{11}$ but the length of rod is increased by $\frac{1}{7}$. ~~and the~~

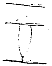
$\frac{4}{28}$

Clarke, Nov. 19. 1880.

To make the area increase in same proportion as length or $\frac{1}{7}$th the end area must be $\frac{8}{7}$ of .15886 sq. in. =
.1815 sq. in. and to have same circumferential dimensions to copper rods, their depth must be
$.1815 \div .4575 = .397$ inches.

which brings the face of the core on armature
$.397 - .376 = .021$ inches farther away from face of field than with Porter-Allen Dynamo.

See page 209
for revised dimensions

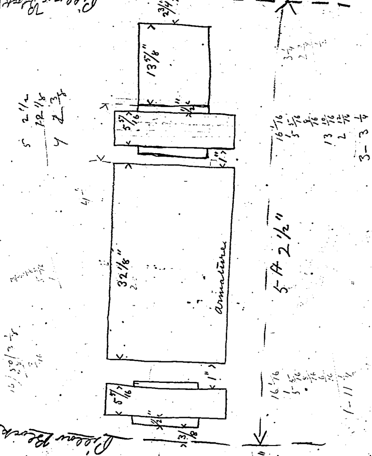


Weight of sleeve for Buckeye dynamo as per bill of lading 325 lbs.

2 . 4
1 . 5 1/8
4
4 . 3 1/4

.69
.009
.80

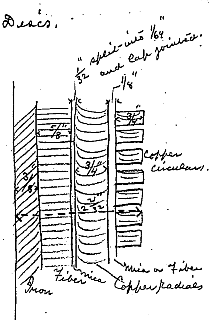
.025
.02
.345
.71
.6


Pillow Block
3/4"
13 5/8"
1/2"
5 5/16
1"
32 1/8"
armature
1"
5 5/16
1/2
3/8
Pillow Block
5 ft 2 1/2"
5 2 1/2
12 1/8
4 2 3/8
16 1/16
1 5/16
13 2
3 3 1/4
3
16 1/16
1 5/16
1 11

2 3/4
13 5/8
1/2
5 5/16
1 1/8
32 1/8
1
5 5/16
1/2
62 1/8
3/8
62 1/2
12) 5 ft 2 1/2"

Nov. 21, 1880. Clarke,

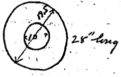
Details of Discs.


1/32" split into 1/64" and lap jointed.
1/8"
5/8"
3/4"
3/4"
3/8"
2 21/32"
Copper circulars.
Mica or Fiber
Copper radials
Mica
Fiber
Iron

Entire width of disc 5 5/16".

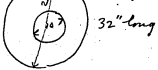
$$\begin{array}{r} 3/4 \\ 1/8 \\ 3/4 \\ 1/32 \\ 5/8 \\ 3/8 \\ \hline 2\ 21/32 \\ 2 \\ \hline 5\ 5/16'' \end{array}$$

Dec. 6, 1880.
Clarke.



The weight of the plates of this armature (Porter-Allen Engine at 600 revs.) is 1600 lbs.

The commutator weighs 164 lbs.



The weight of the plates of the armature for the Buckeye Engine at 450 revs. will be, as calculated from above data; 2300 lbs.

The copper disc weigh approximately 800 lbs. altogether.

Dec. 6, 1880.

Clarke.

Outside this armature there will be 138 copper rods, approximately 34" long and .1815 sq. in. end area (page 131). the contents will be

.1815
34
7260
5445
6.1710
138
49368
18513
6171
851.598 cu. inches

= 270 lbs. of copper on the face of the armature!

1,6) 1,08 (.675 volts to 1 degree
96
120
112
80

1,08) 1,60 (1,48
108
520 degrees.
432 to 1 volt
880
864
120

.40
1.16
240
40
6.40

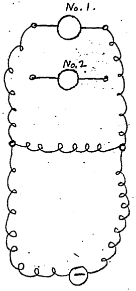
.40) .64 (1.08
.16

$\frac{3}{44}$ (120 40 3

$\frac{3}{2} \div \frac{\cancel{2}}{\cancel{1}}$ $\frac{6}{2}$

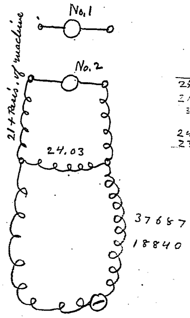
$\frac{3}{2}$ 1.

Test for Motors. Dec. 7



37687
21
37708 + x

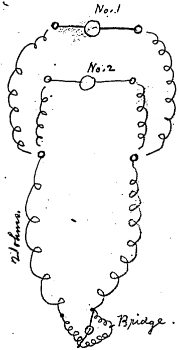
18840
21
18861


No. 1
No. 2
21 + Resis. of machine
24.03
37687
18840

19.96
2.02
1.02
.45
.35
.14
.09
24.03
21
3.03

24.03
23.70
.33

M.G.,


No. 1
No. 2
21 ohms.
Bridge.

The resistance was not perceptibly increased by the wires leading to machines. Total Resis. outside machines 21 ohms.

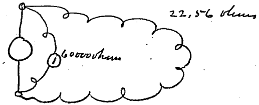
1,48
90
133,20

.675) 90.000(133.333
675
2250
2025
2250
2025

Dec. 8. 1880.

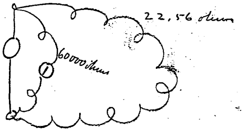
Clarke;

No. 1


22,56 ohms
60000 ohms

N. G.

No. 2


22,56 ohms
60000 ohms

Each machine $\frac{14}{100}$ ohms

No. 1 (965 revolutions.
134° deflection. and .675 Volts
& 1°.

No. 2 (965 revolutions.
136° deflection

675) 110000 (163.
675
4250
4050
2000
201

Second observation

No. 10 { 965 revolutions.
138° deflection.

No. 9 { 965 revolutions.
139° deflection

No. 10, as a dynamo,
No. 9, as a motor,
Resistance only that of the machines and ~~the~~ Short No. 10 leading wires.

No. 10 (Revolution 965.
Deflection 135°

No. 9 (Revolu 886.

N. G.

No. 10 as motor
No. 9. as dynamo

No 10 (Revolutions 938

No 9 (Revo. 965
Deflection 139°

N. G.

Field Increased.

No. 10 Revo. 953
Defl. 147°

No. 9 Revo. 945
Defl. 150°

22.56 ohms outside.

No. 10 as dynamo
No. 9 as motor.

No. 10 Revo. 947
Defl. 145° & 146°

No 9 Revo. 850

N. G.

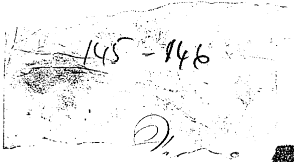
No. 9 as dynamo.
No. 10 as motor.

No. 9 (Revo. 881
Defl. 148°-150.

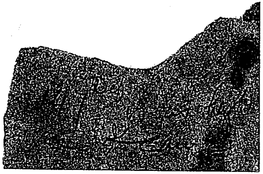
No. 10 (Revo. 932

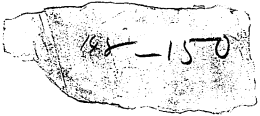
N. G.

[ITEM FOUND IN BOOK]



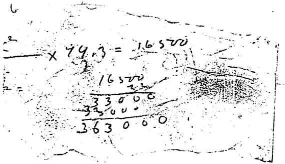
145 - 146





148 - 150

[ITEM FOUND IN BOOK]



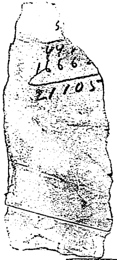
6

× 44.3 = 16500

16500
22

33000
33000

363000



5

44

1666

21105

24) .700 (.03
.72
60
180

Dec. 18th 1880.

965 Revolutions Clarke,

Field and E.M.F.

Def. on Magnet.	Def. in Line.
0 Magnet No. 10.	18 – 18
0	28 – 28
1	40 – 40
2	57 – 52
3	63 – 63
3.5	74 – 74
5	89 89
8	107 107
10	119 119
11	130 130
16	140 140
22	145 145
32	155 155
68	170 – 170

The deflection is 64° for 40 Standard Daniels' Cells.

965 revolutions.

Magnet. ~~Magn~~ Magnet No. 5.

Magnet	Machine	
0	12	12
1	20	20
2	32	-31
3	40	-40
2	50	50
4	59	-60
5	70	70
5.5	85	85
7	105	105
11	122	122
14	131	131
17	138	138
19	142	142
30-31	150	150
-65	165	168

The deflection is 64° for 40 Standard Daniels Cells.

Clarkes

Dec. 13. 1880.

Weight of Copper depositing plates before action of current.

No. 1 — 109.100 gms.

No. 2 — 111.385 gms.

No. 3 — 109.190 gms.

No. 4 — 130.195 gms.

Resistance of leading wires .356 ohms.

Resis. of Magnet No. 5 without leading wires 1.76 - .356 = 1.404

Resis of No. 10 without leading wires 1.865 - .356 = 1.509

Resis of armature in No. 5 without leading wires .507 - .356 = .141

.862
.517
.345
.125
.126

Dec. 14. 1880.

Resistance of armature in machine No. 10 - without leading wires.

.507 - .356 = .141

New test.

Leading wires .348 ohms.

Resis. of depositing cells. Two in series. Plates 1 & 2 - 3 & 4 together .865 - .348 = .517 ohms

Total resistance of circuit including depositing cells and machines.

1.21 - .348 = .862

Dec. 14. 1880

Clarke,

Deflection in high resistance galvanometer direct in circuit of machine No. 10. 140°

No. 10. the dynamo —
No. 5. the motor ;
Speed of motor 895
Speed of dynamo 940

Circuit passed through depositing cells at 3.53 P.M.

Deflection between terminals of dynamo No. 10 140°
Deflection between terminals of motor No. 5, 139°

26.649 : 140 :: 25.927 : -

```
         25.927
            140
        1037080
         25927
26649 )3629780(137
       26649 x
        96488
        79947
        165410
```

26.649
.722
25.927

26.

```
        26.067
           140
       1042680
        26067
26649 )3649380(137
       26649 xx
        98448
        79947
        185010
```

Speed of dynamo
at 3.56 – 940 revs.
Speed of motor
at 4.02
920 revs.

Circuit broken at ~~4~~.03
Run 10 minutes

Weight of copper depositing plates after test.

No. 1	108.320 gms.
No. 2	112.088 gms.
No. 3	109.899 gms.
No. 4	129.410 gms.

$x - a$

$y - a$

$x - a$

$y - a - b - c$

$y - a$

780
785
703
709
4) 2977
.74425

M weighs more than $x - a$

$M - x + a$

N weighs less than $y - a$

$y - a - N$

$\frac{M - x ~~+a~~ + y ~~-a~~ - N}{2}$ 703 6 6

$\bar{1}.8717188$
$\bar{1}.2893660$
0.5823528

.041853

.00032456
.194736

$\bar{1}.8488047$
$\bar{1}.2893660$
0.5594387

.703
.685
.018

3528
3475
53

697
703

703) 18.00 (2
3940

703) 700 00 (
703

3 000
4

697) 3 (4

No. 2 – Weight after exp. 112,088
" " before exp. 111,385
Deposited in 10 minutes. .703 gm

No. 1 – Weight before exp. 109,100
" " after 108,320
Taken off in 10 minutes. .780 gm

No. 3 – Weight after exp. 109,899
" " before exp. 109,190
Deposited in 10 minutes .709 gm

No. 4 – Weight before exp. 130,195
" " after exp. 129,410
.785 gm

Assume the true amount of deposited copper to be the mean we have

$$\frac{.703 + .780 + .709 + .785}{4} = .74425$$

10 = 1

265.27 : 264.4 :: 940

264
940
10560
2376
265) 248160 (93
2385
960
795
1650

.000325
600
.07420

.00031.75
.0002 50
6 3
3 4 5
3 2 3 5

.675
140
27000
675
94.500

26.65
.862
25.788

94.5

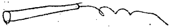
1.9734318
~~1.5497510~~
1.4236808
2.1

Ī.8450980
Ī.2953471
Ī
0.5497509

26.65 : 25.75 :: 940

265.27
.862
264.408

4194000
235
705 00 (91
26.65) 24205
23985
2200
2820



24.862
.862
24.

The veber of current deposits

.000325 × 60 × 10 = .1947 gms.

in 10 minutes, The total current is therefore

.74425 3.8225
~~3.5765~~
.1947) 7.0600
5.8292
12.3080
7.7870
15.2100
13.8928
12.8920
11.6844
9760

Current = 3.8225 Vebers.

Total Equivalent Resis = 94.5 ÷ 3.8225 = 24.722

The E.M.F. is outside dynamo.

outside dynamo 140 × .675 = 94.5 Volts

94.5 1.9754318
2
3.9508636
44.3 1.6464037
5.5972673
24.722 1.3930790
16003 ft. lbs. 4.2041883

Energy in line outside the dynamo.

Clarke.

Tests Dec. 15, 1880.

Weight of depositing plates before test

No. 1	108,320 gms.
No. 2	112,0~~85~~ 78* gms.
No. 3	109.899 gms.
No. 4	129.410 gms.

To see if the free H_2SO_4 in the solution dissolves the plates; a plate is immersed in that solution

Immersed at	12.50 P.M.
Weight before	27,9883 gms.
Taken out at	1,55 P.M.
Weight after	27.9847 gms

An apparent loss of 0.0036 gms.

* The weight was brought to this by exp. page 175.

Plate No. 2

immersed at 2.40 P.M.

Weight before	112.088 gms.
taken out a 5. P.M.	
Weight after	112.078 gms.
Lost in 2h.20m	0.010 gms.

The loss for 10 minutes, which was the duration of the test, could not be detected with the balance.

Dec. 16, 1880.

Clarke.

Test of Motor and dynamo.

Weight of depositing plates before the test.

No. 1	108.320 grms.
No. 2	112.078 grm
No. 3	109.899 grms
No. 4	129.410 grms.

These plates were multiple-arced, 1 & 2; 3 & 4 in same cell.

The dynamo was magnet No. 1. Armature No. with resistance of $\frac{55}{100}$ ohm.

The motor was magnet No. Armature No. with resistance of .14 ohm. Drove a fan blast.

675
243
2025
2700
1350
164025

875
675
4375
6125
5250
5.90625

262
.675
1310
1834
1572
2 | 176.850
83.4

The deflection between terminals of Magnet No. 1 was
8½° — 9° = 8¾° = 5.9 Volts

.675 Volt to 1°.

The motor magnet being in every respect like No. 1 must have had the same E.M.F. at the terminals.

Deflection between terminals of dynamo when doing no work 243°. 164 Volts.

Current turned through depositing cells at 3-36 P.M.
Current turned off at 3-43 P.M.
Duration 7 minutes –

134° 142° 135°

134
675
678
938
804
89.

142
675
714
994
852
951

1,832
.951
2,783

,915
1,995
2,910

.675
134½
2700
2025
675
337
90. 87

The deflection outside the dynamo and depositing cells was 134° — 135° = 134°.5

The deflection between the terminals of dynamo was 142.°

Weight of plates after experiment.

No. 1	106 .488 gms.
No. 2	112 ,993 gms
No. 3	110 .850 gms
No. 4	127 .415 gms

No. 1
108, 320
106, 488
" Increase 1, 832 gms.

No, 2
112, 993
112. 078
" decrease .915 gms

No. 3
110, 850
109, 899
" Increase .951 gms.

No, 4
129, 410
127, 415
" decrease 1.995 gms.

33000)151500(4.6
132000
195000

Take the average as the true amount—

1.832
.915
.951
1.995
2)5.693
2.8465 gms in 7 m.

The deposit for seven minutes per weber current is
.000325 × 60 × 7 .13650 gms.

The current was therefore

log. 2.8465 0.4543112
log. .1365 $\bar{1}$.1351327
1.3191785
20.85

Current = 20.85 webers.

The total E.M.F. was 164 Volts
E.M.F. × C × 44.3 = Energy

log. 20.85 1.3191785
log. 164 2.2148438
1.6464037
5.1804260
151500

Energy total 151500 ft. lbs.
= 4.6 horse power.

$$\frac{\text{Total Volts}}{\text{Current}} \quad \frac{164}{20,85} = \text{Resis.}$$

log. 164

log. 20,85

7,8644

2,2148438
1,3191785
0,8956653

Resis. = 7,8644

The total volts are 164 but when the current was flowing the volts at the terminals of dynamo were 95,85, showing that there had been a fall of 68.15 on .55 ohm. This fall disagrees with the fall on the total 7.86 ohms and there must have been much polarization.

The test is on the whole unreliable.

164
875

.55) 69.00(107
55
400

4.6
52
92
230
239.2

164) 239.2(1.45
164
756
656
940

5.1) 1.10(.216
102
80
51
290

6/9

If 164 Volts are given by the dynamo of $\frac{55}{100}$ ohms at 950 revs, the motor of $\frac{[illegible]4}{100}$ ohms will give 82 Volts at 950 but as its speed was 600 the Counter E. M. F. is

$x : 600 :: 82 : 950$

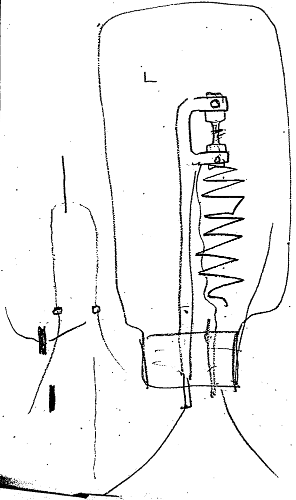
600

950) 49200 (52.
4750
1700

Counter E. M. F. = 52 Volts, then of the total energy on the line or 4.6 horse-power $\frac{52}{164}$ of 4.6 or 1.45 H. P. is developed by motor and as it takes .35 H. P. to run the ~~dynamo~~ motor at that speed the useful effect is

1.1 Horse-power,

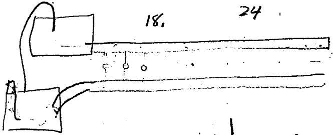
so that some 5.1 H. P. are consumed in all and the ratio of useful effect is 21.6 %.


L

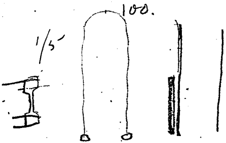
9.

6 inch.

12



25.



$\frac{14}{10}$

82
82
164
656
6724
44.3
81 72
26896
26896

1,4) 296672 (3.2 / 211900
28
16
14
26
14
127
126

33 ~~00~~) 212~~900~~ (6
208
3

Let a $\frac{14}{100}$ armature gives 82 volts at 950 revo.

The resistance with an equal motor will be $\frac{28}{100}$ but if we wish $\frac{8}{10}$ conversion the total resistance must be 1.4 ohms and we have

$$\frac{82^2}{1.4} \times 44.3 = 211.900 \text{ ft. lbs.}$$
$$= 6.1 \text{ H.P.}$$

but 1/2 H.P. is consumed in friction and local currents leaving 5.6 H.P. but total 6.1 + .5 = 6.6.

6.6) 5.6.0 (.8
5.2.8
320

Test = Saturday Dec. 18, 1880,
Clarke,

Weight of Copper plates before test.

No. 1	96,878 gms.
No. 2	99.461 gms,
No. 3	84.177 gms.
No. 4	113.695 gms.
No. 5	117,745 gms.
No. 6	117.818 gms.
No. 7	119.145 gms.
No. 8	120.455 gms.

With cells in

Speed of dynamos 935 revs.
Speed of motor 1500 revs.

3 dynamos $\frac{14}{100}$.
1 motor $\frac{14}{100}$.

Time current was thrown through depositing cells 8-55 a.m.

.675
.145
3275
2700
675
97.775

.675
.245
3375
2700
1350
165.375

.675
.148
5400
2700
675
99900

935
3
2805

2805) 15700(.56
14025
16750
16830

.675
.248
5400
2700
1350
167.400

Time current was thrown out 9-05 a.m.

Duration of test 10 minutes;

Deflection at terminals of motor with cells in 245.0

.675 Volts to 1°. 165.38 Volts

Weight of copper plates after test

No. 1	95,891 gms.
No. 2	98.590 gms.
No. 3	84,943 gms.
No. 4	114,580 gms.
No. 5	118,531 gms.
No. 6	118,862 gms.
No. 7	118.047 gms.
No. 8	1.19.528 gms

From 3 & 4 - 5 & 6 an upward motion of the fluid noticed.

~~935~~

100 Volts at ~~1000~~ revs.

for dynamo.

Suppose motor at 600 revs.

then counter E.M.F. is 60 volts

dynamo 1 unit of work at ~~[illegible]~~ unit

~~speed at one revs~~, strain = 1

~~1000~~

Motor does $\frac{3}{5}$ unit but at $\frac{3}{5}$ speed

and strain is $\frac{3}{5} \times \frac{5}{3} = \frac{15}{15} = 1$

Suppose two dynamos

200 Volts

The two do 1 unit at unit speed

and $\frac{1}{2}$ strain on each belt

Motor does $\frac{3}{10}$ work but at

$\frac{3}{5}$ speed and unit strain is

$\frac{3}{10} \times \frac{5}{3} = \frac{1}{2}$

Suppose three dynamos

300 Volts,

The three do 1 unit at unit speed

and $\frac{1}{3}$ strain on each belt.

Motor does $\frac{1}{5}$ work but at

$\frac{3}{5}$ speed - and unit strain.

$\frac{1}{5} \times \frac{5}{3} = \frac{1}{3}$. $\frac{4}{5}$ work

Suppose 800 revs 80 volts

---

with cells out.

Speed of dynamos 935 revs

Speed of motor 1570 revs

Deflection at terminals of motor with cells out, 2480 or 167.4 Volts

Change of weight in plates.

No. 1	lost		.987 gms.
No. 2		1.858	.871 gms.
No. 7			1.098 gms.
No. 8		2.025	.927 gms.
No. 3	gained		.766 gms.
No. 4		1.651	.885 gms.
No. 5			.786 gms.
No. 6		1.830	1.044 gms.

1.858
2.025 ——— 3.883
1.651
1.830 ——— 3.481
.402
2) 7.364

Average 3.682 gms. in ten minutes.

16509
49500

.167

.179

145210
49500
194710) 1103300 (.56
973550
1297600

unit work

$\frac{1}{3}$ [illegible] in each [illegible]

$\frac{4}{15}$ work at $\frac{4}{5}$ speed

$\frac{\cancel{4}}{\cancel{15}_{3}} \times \frac{5}{\cancel{4}} = \frac{1}{3}$

138550
136330
2220
4
8880
14) 8.745

136330
8880
145210) 1363300 (9.4
1306890
564100

18.911
.14
75644
18911
2.64754

The deposit per weber of current for 10 minutes is

$.00032456 \times 60 \times 10 = .1947$

---

log. 3.682 0.5660838
log. $\bar{1}$.2893660
18.911 1.2767178

Current = 18.911 webers.

Volts. log. 165.38 2.2184830
log. 18.911 1.2767178
log. 44.3 1.6464037
13855.0 5.1416045

Energy developed in motor
13855.01 ft. lbs.

Volts log. 165.38 2.2184830
log. 18.911 1.2767178
8.745 0.9417652

Resistance in motor
8.745 ohms – but .14 only is true resistance the rest

n dynamos , 1 motor
E Volts , e volts
nE Volts , $\frac{e}{E}$ Speed

$\frac{1}{n}$ = strain on dynamo belt

$\frac{e}{nE}$ = work by motor

but work is done at $\frac{e}{E}$ speed

Strain on motor = $\frac{\text{Work by motor}}{\text{Speed}}$

$$'' = \frac{\frac{e}{nE}}{\frac{e}{E}} = \frac{1}{n}$$

935
3
2805

1500

being due to counter E.M.F.

x : 138550 ft. lbs. :: 8.605 : 8.745

log 138550 5.1416045
log 8.605 0.9347509
6.0763554
log 8.745 0.9417652
136330 5.1345902

Consumed in work by motor 136330 ft. lbs.

~~This is at a speed of 1500 revo. and the drag is therefore in the ratio of $\frac{136330}{1500}$, Each dynamo has this same drag per revolution and there being 3 at 935 revo. we have total work in dynamo drag~~

~~$\frac{136330}{1500} \times 3 \times 935 =$~~

The field in dynamos were not in same conditions as in motor.

2805) 15000 (5
14025
15

165
1950

33000) 304440 (9,2
297
70

138550
6813
145363

254940
136330
118610

16500
150
825000
16500
2475000 (26000
95) 247 5
190
570
570

198520) 536910 (27
397040
1398700
1389640

304440) 11033000 (362
913320
1899800
1826640
731600

log 136330
935
3

1500
254940

5.1345902
2.9708116
0.4771213
8.5825231
3.1760913
5.4064318

Drag on dynamos

254940 ft. lbs.

By previous exps the dynamo at 935 revs takes in friction 1/2 H.P.

∴ 254940 + 49500

= 304440 ft. lbs.
= 9.2 H.P.
= total energy expended.

The motor at same ratio will take at 1500 revs

150/95 of 16500 = 26000

The useful effect of motor will be 136330 − 26000
= 110330 ft. lbs.
= 3 1/3 H.P.
or ~~36~~% useful.
57%

3.14
30
94.20
2000
188400000
27
131888
37688 00
72) 5086800 (70000
504
2

162.74
965
81370
97644
146466
157044.50 (104.7 Volts at 965 revs.
15
70
60
104

.675
.14
27000
675
94500

.675) 104.718 (155° = deflection.
675
3720
3375
3450

94.5
1550
47250
4725
945
965) 146.475 0 (152
965
4997
4825
1725

70.125
1500
5012500
1025
965) 150375 00 (155
965
5387
4825
5625

.675
150
3750
32
72
110.250

165.3

~~248~~
~~162~~
~~167.4~~

Deflection at terminals of dynamos 239°,

at 965 revs. a $\frac{14}{100}$ machine gives 94.5 Volts and at 1500 we have

94.5
1500
472500
945
965) 141750 00 (146.9
965
4525
3860
6650
5790
8600

at 1500 = 146.9 Volts
This then was the counter E.M.F. at that speed.

~~165~~.38
~~2~~.64
162.74 Counter E.M.F.

15535
1500
7767500
15535
935) 2330250 00 (24800
1870
4602
3860
7425

21,838
3,1416
131028
21838
87352
21838
65514
138)68.606 2608(.497
552
1340
1242
986
966
202

27
23
50

466
445
2914
457
397
3199
4113
1371
25)18142(725
175
64
50
142

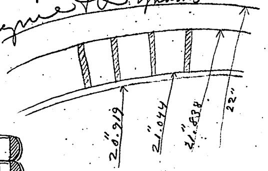
21,044
3,1416
126264
21044
84176
21044
63132
132)66.1116 8304(.479
552
1091
966
125
1242

32)1.00000(.03125
96
40
32
80
64
160

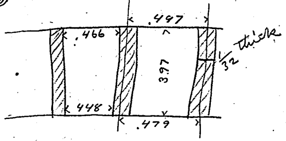
497
03125
465 7.5

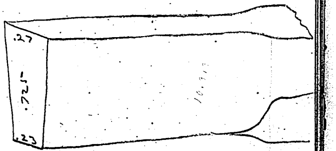
479
03125
447 7.5

Buckeye Engine + Dynamo Dec 31, 1880.


20.919"
21.044"
21.838"
22"

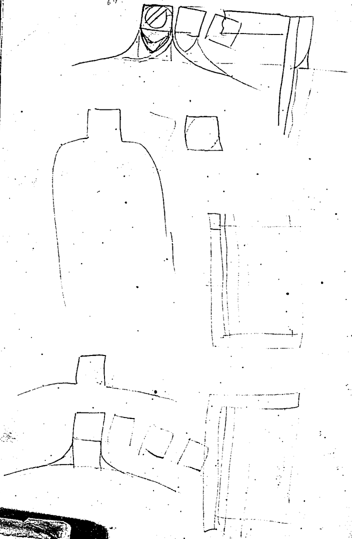
B


.497
.466
.448
.479
3.97
1/32 thick

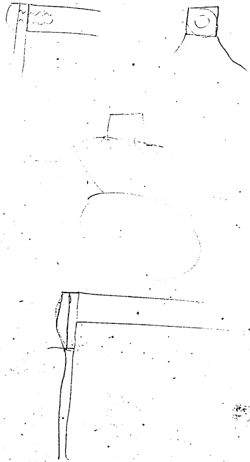


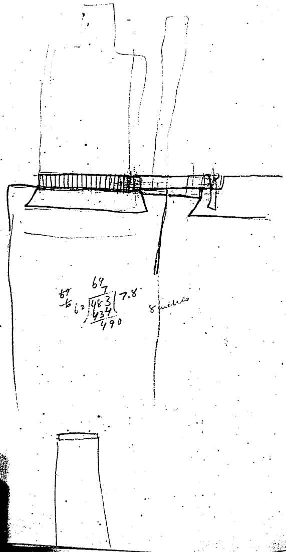
$\frac{1}{16} = .0625$

$\frac{1}{64} = .015625$



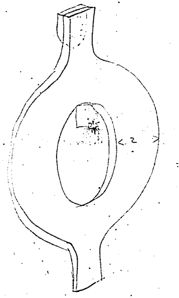
4
1
5
65
45
20
64) 345 (15½
320
250





69
7
69
-6 62 | 483 | 7.8
434
490

8 inches



Clarke Jan. 7, 1880

For dynamo $mS + nE^2 + EC$

but EC is the total energy of induction developed in the circuit and if D is the armature drag we have

$$DS = EC$$

For motor field in same condition $eC - ms - ne^2$

but drag is same as in dynamo

$$Ds = eC$$

For ratio of work by motor to total work

$$r = \frac{eC - m's - ne^2}{EC + mS + nE^2} \quad \text{or}$$

$$r = \frac{Ds - m's - ne^2}{DS + mS + nE^2}$$

In differentiating mS and nE^2 are constant also S

Now e varies as S $\quad e = bS$

Therefore

$$\frac{E'(E - E')}{R}$$

~~$W = E^2 - EE'$~~

~~$dW = 2EdE -$~~

$$W = EE' - E'^2$$

$$dW = EdE' - 2E'dE'$$

$$\frac{dW}{dE'} = E - 2E' = 0$$

$$E' = \frac{E}{2}$$

$$r = \frac{Ds - ms - nb^2s}{DS + mS + nE^2}$$

mS, nE^2, S, m, and nb^2 are constants under differentiating.

$$dr = \frac{SdD + Dds - mds - nb^2ds}{SdD}$$

~~$dr = 1$~~

$$dr\,SdD = SdD + Dds - mds - nb^2ds$$

$$SdD(dr - 1) = ds(D - m - nb^2)$$

25 lamps of 125 ohms.

$\frac{14}{100}$ ohms machine

deflection at terminals of machine with one light of 16 candles = 168°

Total deflection

```
     125,19
        168
   --------
    100111.2
    75084
  12514
125)2102 3.52(168.19
   125 x  x x 7
   ---
    852
    750
    1023
    1000
      235
      125
      1102
      1105

Total 168°,19
```

With 25 lamps in the external resistance is 5 ohms and deflection at terminals of machine

```
       168°,19
              5
5,14)840.95(163°.61
     514 x x
     3269
     3084
      1855
      1542
       3130
       3084
         460
```

Suppose 8 lamps of 125 ohms total external resistance is 15.625 ohms and with 168° deflection at terminals of machine the total E.M.F. is

```
       15.765
         168
      ------
       126120
       94590
       15765
15.625)2648.520(169°.5 volts
       15625  x
        108602
         93750
        -------
         148520
         140625
           78960
           78225
```

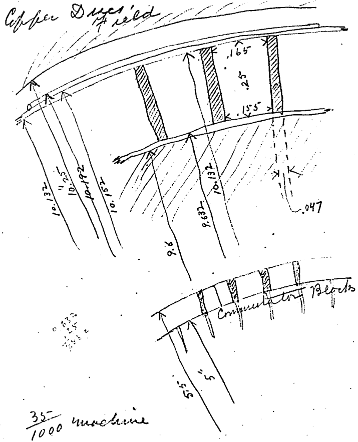
Now if the total E.M.F. be 169°.5 Volts and 24 lights be thrown in the external circuit, is 5.208 ohms. and deflection at terminals is

169°.5
5.208
13560
3390
8475
5.348) 882756 (166°.1
5348
34795
32088
27076
26740
3360

168°
165°.1
~~16~~ 2°.9

.675
2.9
6075
1350
19575

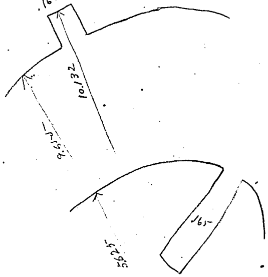
19

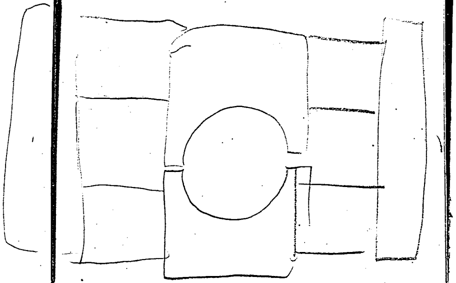

Copper Discs
Field
.165
.25
.155
.047
10.132
11.25
10.192
10.152
9.6
9.632
10.132
Commutator Blocks
5.5
5"

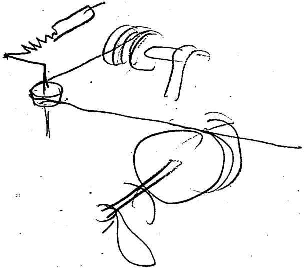
35/1000 machine

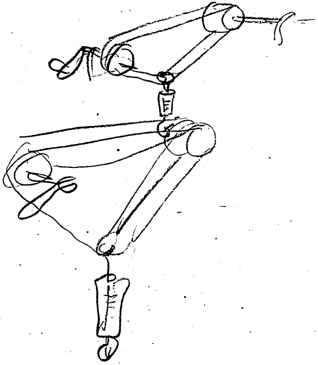
Clarke,

Copper Discs. Jan. 19, 1880.


.165
10.132
9.655
.165
5.625







$x - a$

$y - a$

$M > x - a$

$N < y - a$

$$\frac{M - x \cancel{+N} + y - N}{2}$$

$$\frac{M - x \cancel{+a} + y \cancel{-a} - N}{2}$$

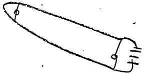
130
30
900
3
30
900

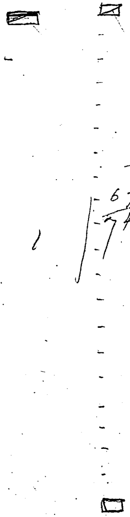
15
.08
1.28

130
130
3900
130
16900
44.3

56700.0
67600
67600
1.28)74867000√5,849,000
64
1086
1024
627
512
11.50
115

33000) 5849~~000~~(17.7
33
254
231
239

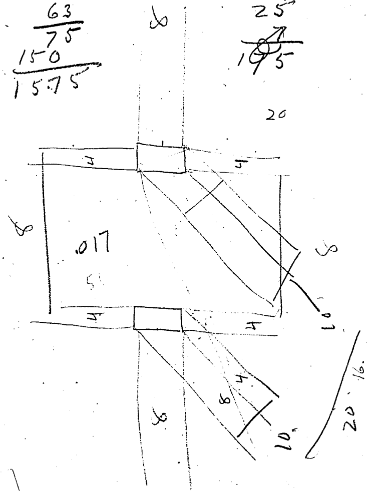




130
130
3900
130
16900
67600
67600
743,600

$$\begin{array}{r} 25 \\ 63 \\ \hline 75 \\ 150 \\ \hline 15.75 \end{array}$$

$$\begin{array}{r} 17 \\ 8 \\ \hline 25 \\ \cancel{8}\,7 \\ \hline 1\cancel{9}5 \end{array}$$

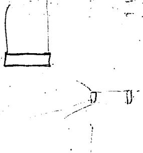


Face 8
Sides 17
Average ~~1~~5.75
17.7

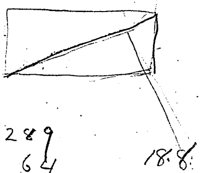
$$\begin{array}{r} 30 \\ 30 \\ \hline 900 \end{array}$$

$$R = \frac{10.64\,Z}{m}$$

$$900\overline{)10.64}(.012$$
$$\begin{array}{r} 900 \\ \hline 1640 \end{array} \quad .012\overline{).140} \quad 12$$

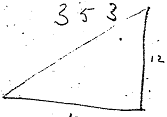


5 3



17
8

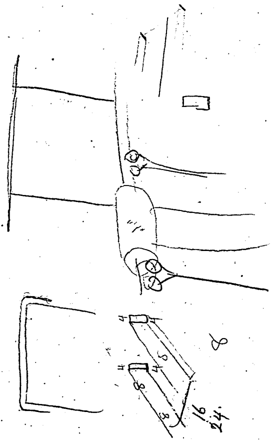
289
64
353



289
444

64
32

12
5.7
17.7


4
8
4
4
8
8
16
24
8